Snap-Together Motion : Assembling Run-Time Animation

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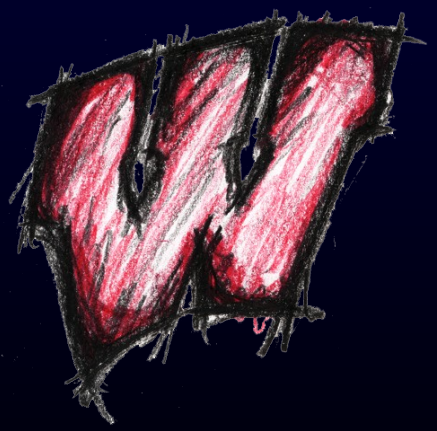


Motion Synthesis in Virtual Environments

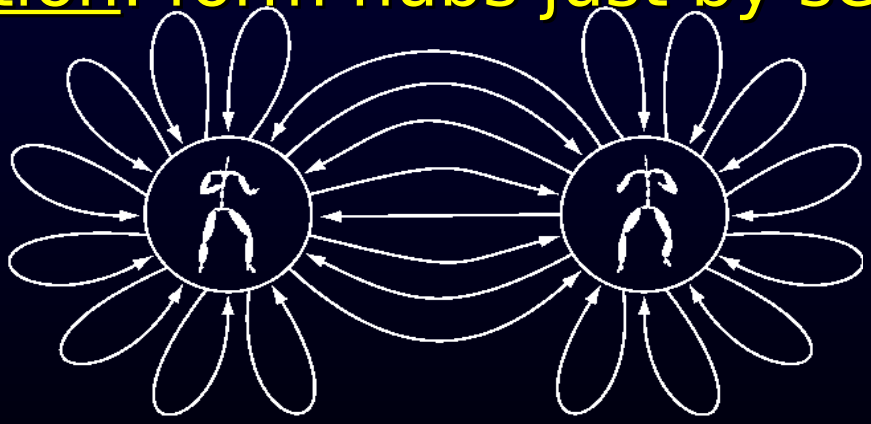
Requirements

- Realism
- Little run-time overhead
  - Also need to do rendering, physical simulation, agent planning, etc.
- Control
  - Know what is available
  - Issue simple commands to characters

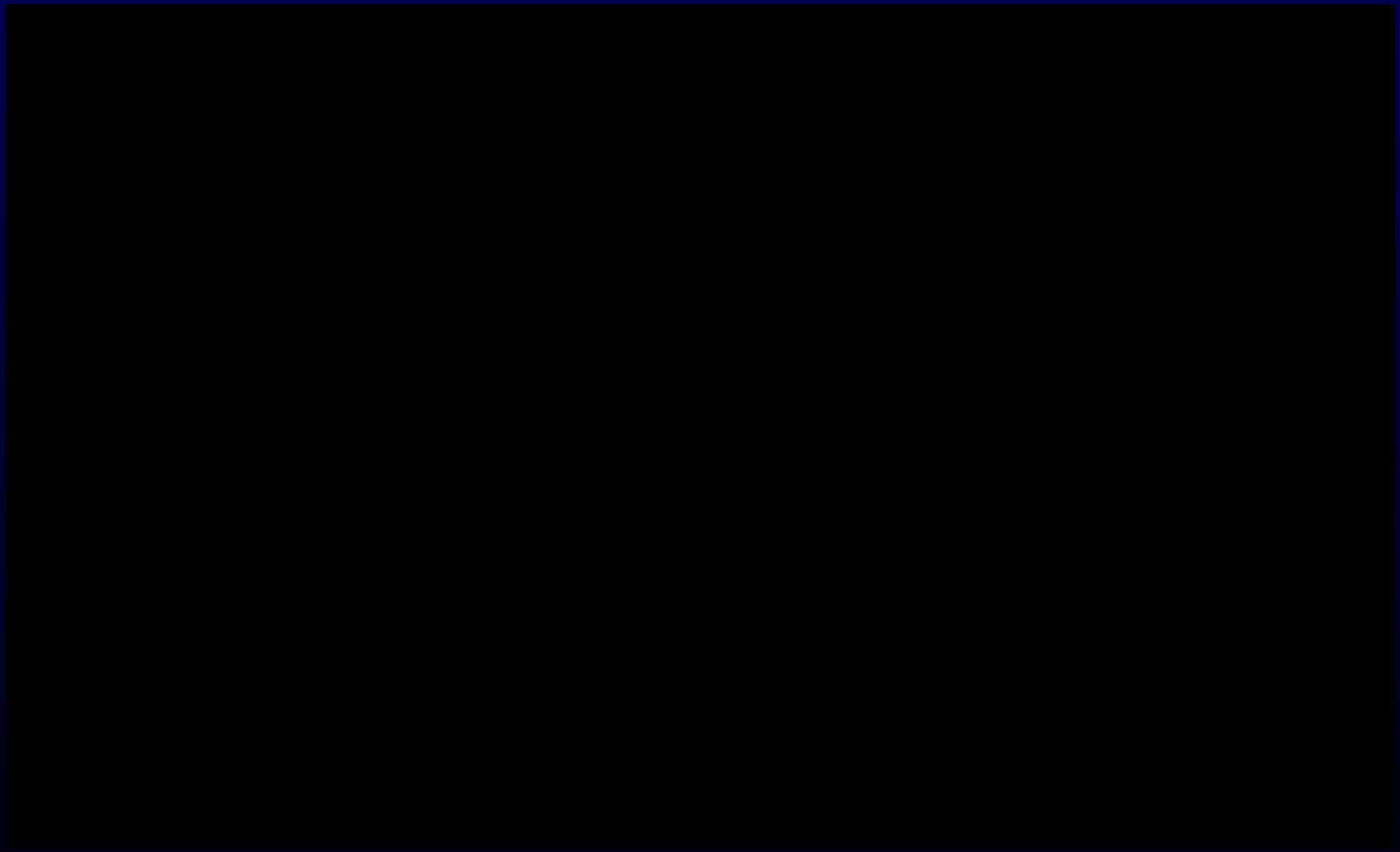
Snap-Together Motion

Build a graph from a motion database

- Speed: attach motion through concatenation
- Quality: smooth transitions, constraints enforced
- Control: high-connectivity graphs with a small number of “hub” nodes
- Automation: form hubs just by selecting a pose



Example



Talk Outline

1. Related work
2. Overview
3. Graph construction and motion synthesis
4. Results

Related Work: Motion Synthesis

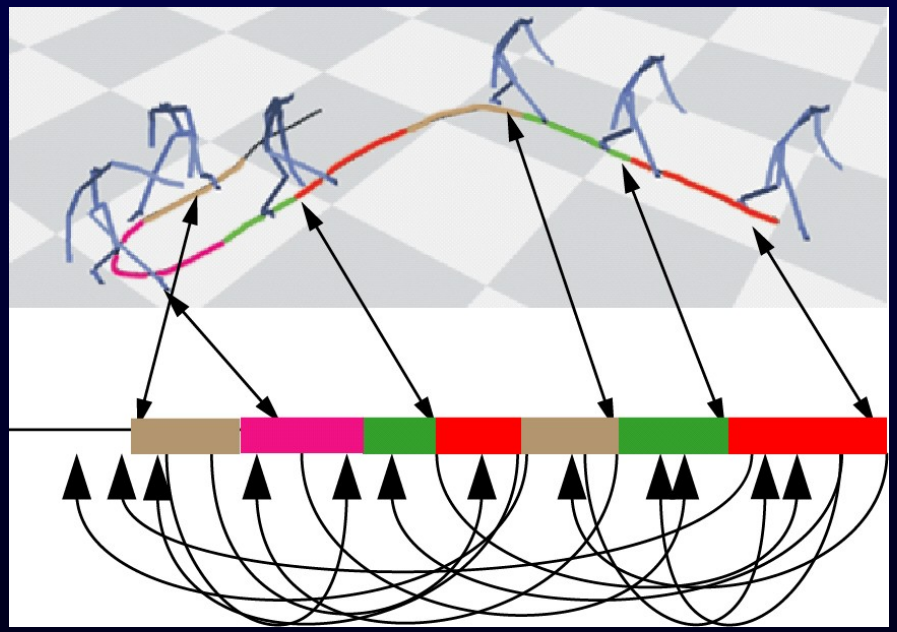
- Move trees
  - Mizuguchi et al., 2001
  - Labor-intensive construction
- Mathematical models of motion
  - Brand and Hertzmann, 2000; Li et al., 2002
  - Looser quality guarantees; harder to control
- Motion interpolation
  - Rose et al., 1998; Park et al., 2002

Related Work: Automatic Graph Construction

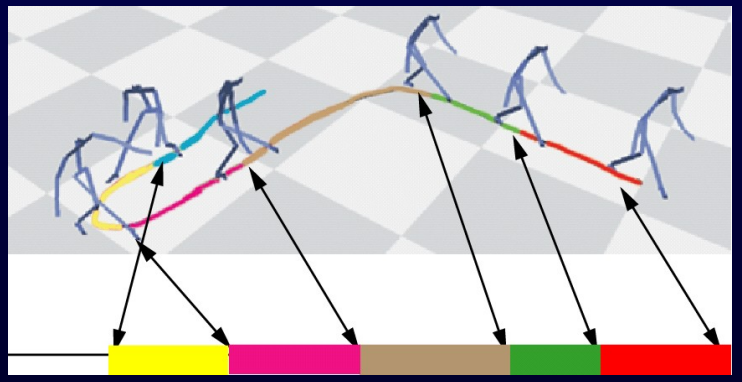
- Arikan and Forsyth, Kovar et al., Lee et al.
- Add transitions wherever motions are similar
  - Unstructured graphs
- Create new motions via search
  - Slower
  - Offline
  - Can only produce a “best fit”

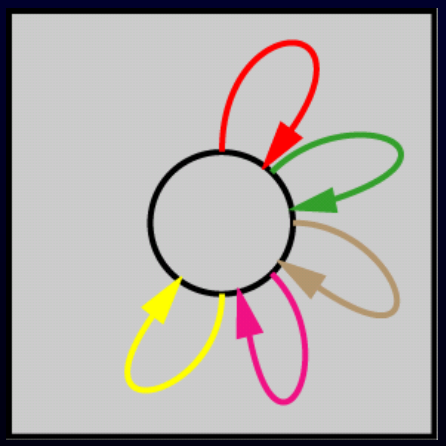
Automatic Graph Construction (cont.)

Unstructured Graph



Structured Graph





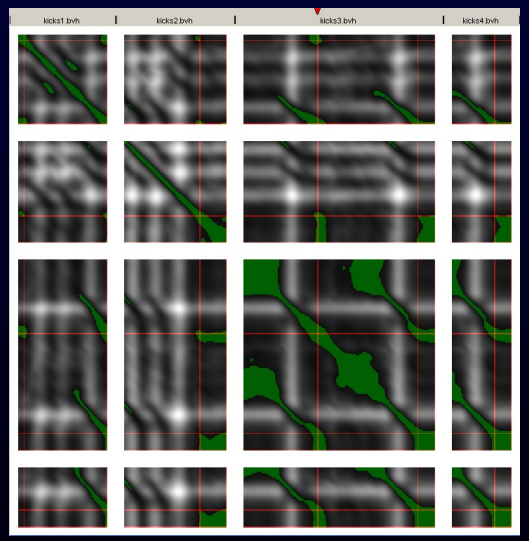
Overview

Find groups of similar frames (*match sets*) and create multi-way transitions

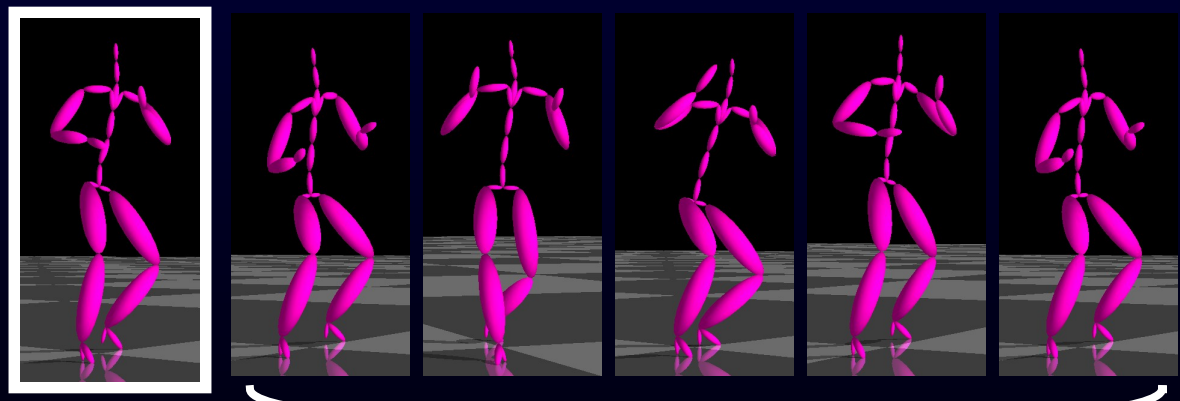
1. Pick a “base” frame or have the system suggest one
2. Find similar frames and add displacement maps so motions are identical at match frames.
3. Ensure constraints remain enforced

Graph Construction

- Hub node based on base frame
  - Match set: a set of similar frames
    - ✓ Distance metric: point cloud matching [Kovar *et al*]
    - ✓ Local minima below a user-specified threshold
- Heuristic base frame selection
  - The frame that has the largest match set



Error matrix



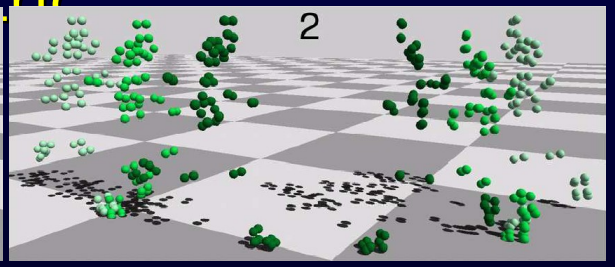
Base pose

Match set

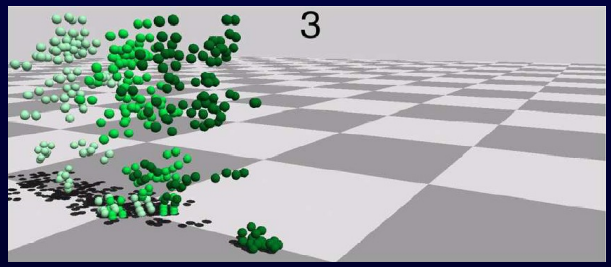
Averaging Poses

- Coordinate frame alignment
  - Aligning match frames into a common coordinate frame
  - Coordinate frame alignment method used in the distance metric

Two sequences of poses



Point clouds

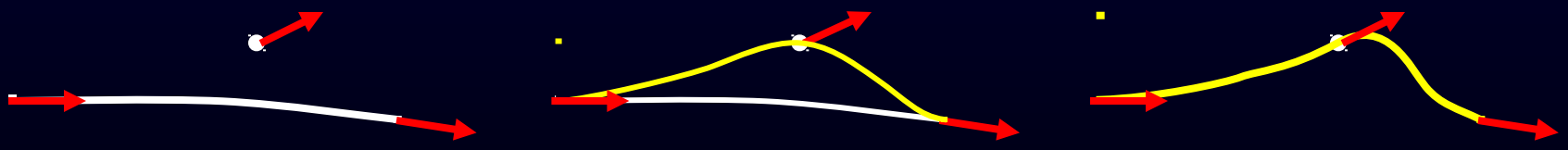


Transformed

- Averaging joint angles
  - Orientation estimator [Park, Shin, Shin]
    - ✓ Quaternion with the minimum sum of squared distances
    - ✓ Coordinate invariant average

Motion Adjustment

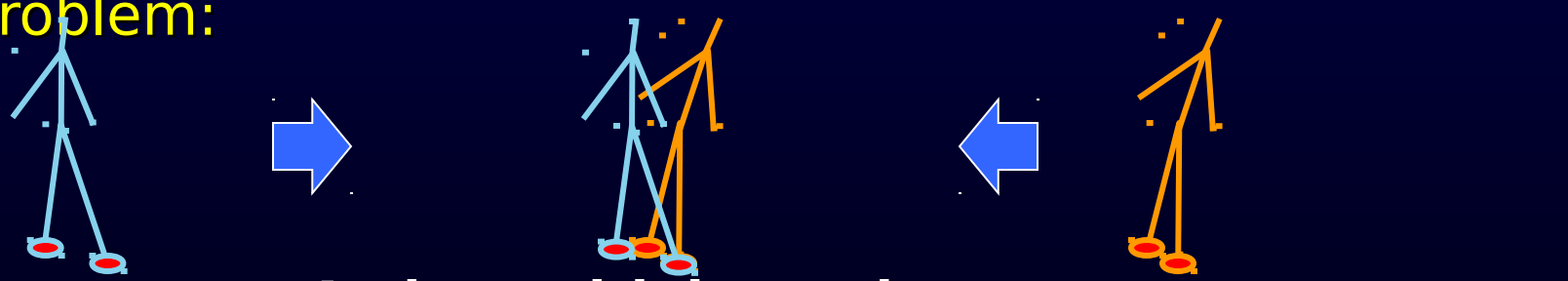
- Displacement map
  - C^1 continuity in transitions
    - ✓ Making the match frames have the average velocities as well as the average pose
  - Two-level displacement map
    - ✓ Coarse knots for fitting the pose
    - ✓ Denser knots for fitting the velocity



Original motion **Posture fitting** **Velocity fitting**

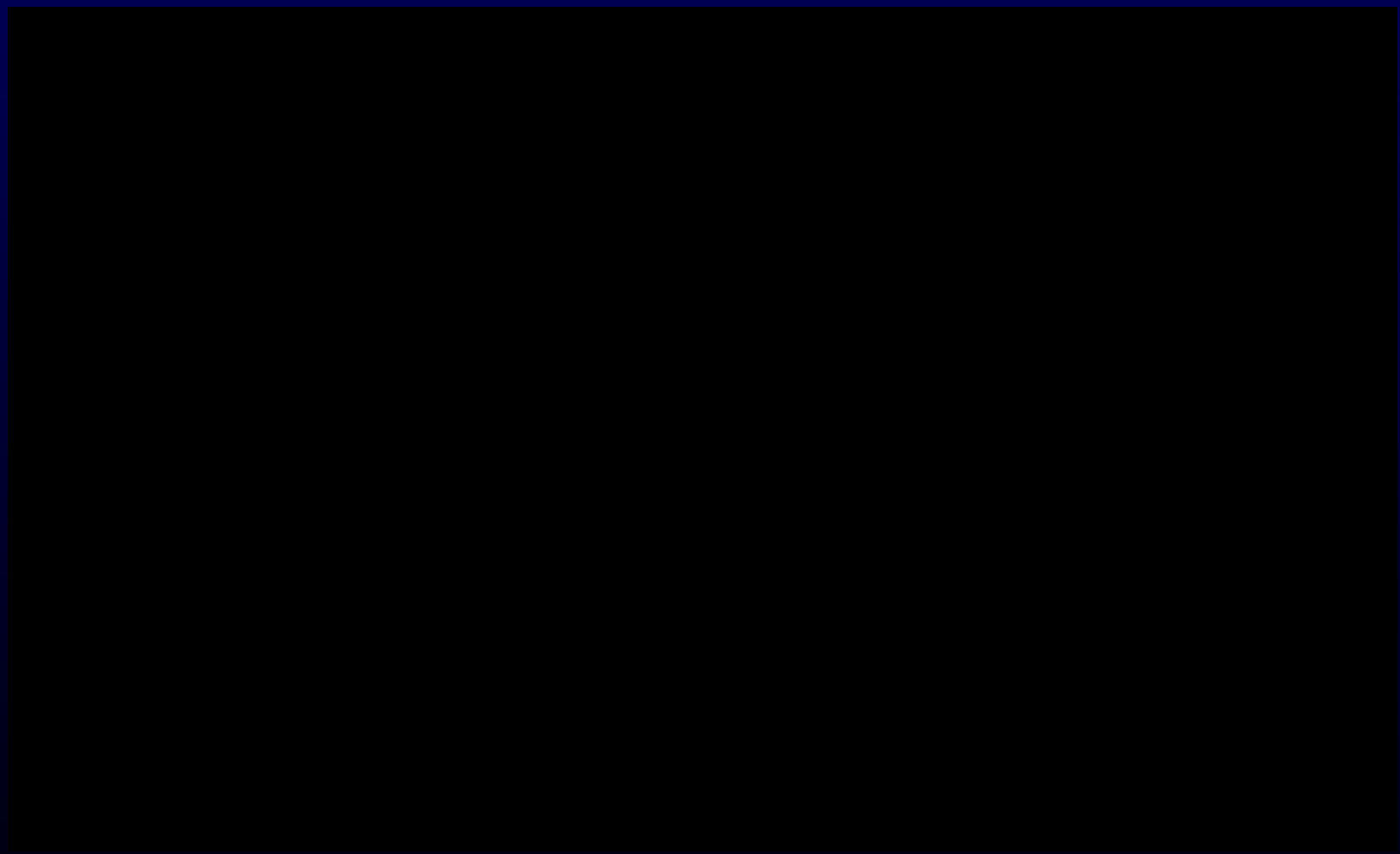
Constraints

- Enforcing kinematic constraints
  - Enforce constraint on match frames
  - Enforce const. in the rest of motion fixing match frames
  - Footskate cleanup [Kovar et al]
- Constraint inconsistency
  - Problem:



  - Solution:
    - ✓ Grouping hub nodes with possible conflicts
    - ✓ Determining a single constraint position over the group

Authoring

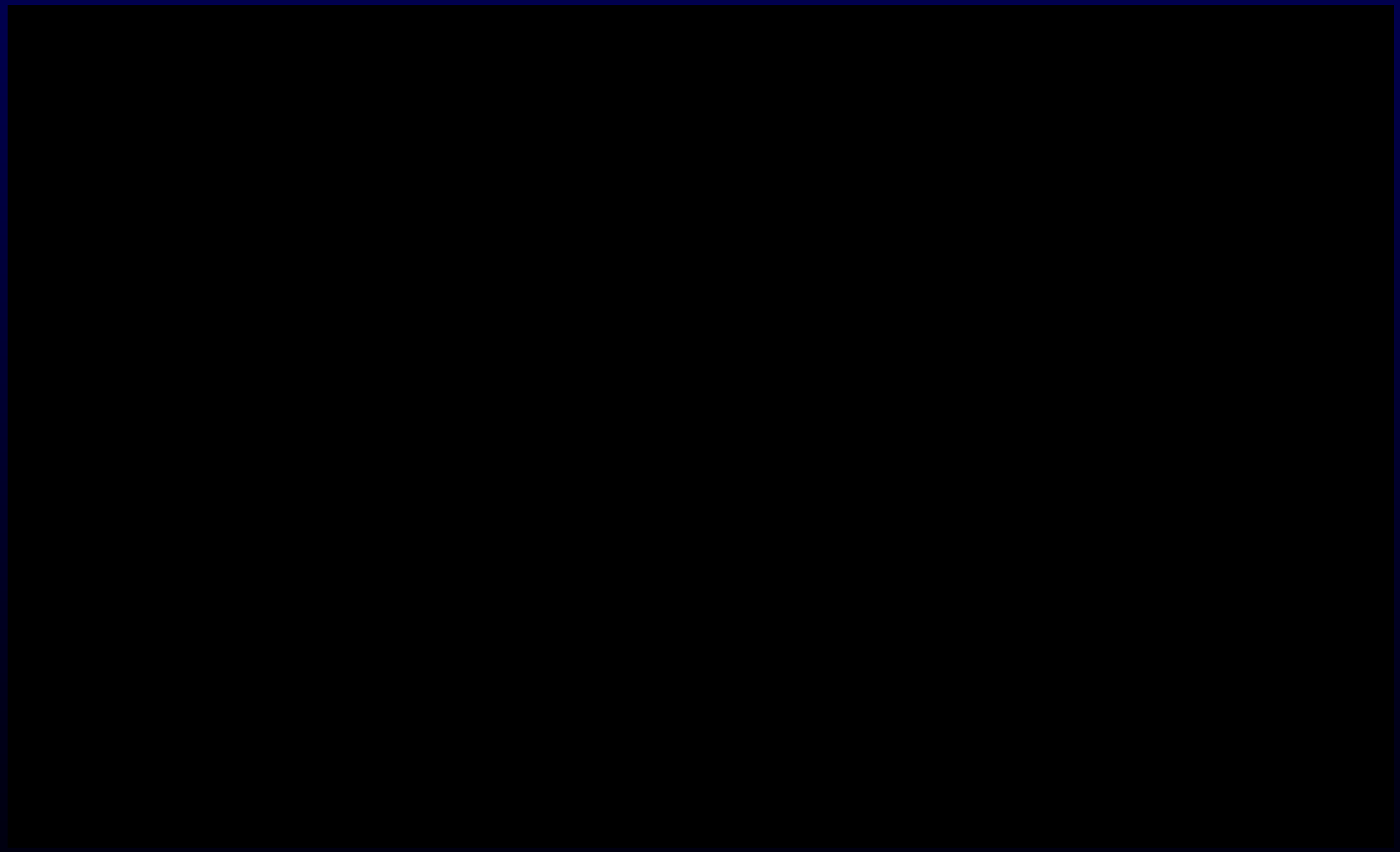


Runtime Motion Synthesis

- A motion clip
  - Motion data + nodes + coordinate transform
- Motion synthesis
  - Apply coordinate transformation
  - Concatenate clips
- Control
  - Application dependent control
    - ✓E.g. Keyboard or joystick

Results

- Video



Summary

- A motion synthesis frame work
  - Controllability with highly connected graph
  - Preprocessing everything in authoring step
  - Automated authoring

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